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**ACCEPTANCE OF EARPHONES IN CHILDREN 12- TO 24-MONTHS OF  
AGE DURING VISUAL REINFORCEMENT AUDIOMETRY**

**by**

**Allyson Davis**

**A Capstone Project  
submitted in partial fulfillment of the  
requirements for the degree of:**

**Doctorate of Audiology**

**Washington University School of Medicine  
Program in Audiology and Communication Sciences**

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**Approved by:**

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***Abstract: Insert and circumaural earphones were used during visual reinforcement audiometry with children 12-to 24-months of age. Acceptance of earphones was determined by the number of ear specific thresholds obtained and by audiologist subjective ratings. Results indicate that children in this age range accept both types of earphones; however, significantly more ear specific thresholds were obtained using insert earphones compared to circumaural.***

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**Abbreviations**

ANOVA	Analysis of Variance
dB	Decibels
FMT	Frequency Modulated Tone
HL	Hearing Level
kHz	Kilohertz
MLV	Monitored Live Voice
MRLs	Minimum Response Levels
NBN	Narrow Band Noise
SAT	Speech Awareness Threshold
SL	Sensation Level
VRA	Visual Reinforcement Audiometry

Early and accurate identification, diagnosis, and management of childhood hearing loss minimizes the negative impact it has on speech, language, academic, and psychosocial development (Madell, 2008; Moeller, McCleary, Putman, Tyler-Krings, Hoover, & Stelmachowicz, 2010; Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998). Hearing status of 12- to 24-month-old children is assessed through behavioral audiometric testing with the goal of obtaining ear specific hearing thresholds for speech and tonal stimuli to allow for an accurate diagnosis. For infants with permanent hearing loss these data are necessary for the appropriate fitting of amplification devices. Within this age, visual reinforcement audiometry (VRA) is used to accurately diagnose both the type and degree of hearing loss (Culpepper & Thompson, 1994; Day, Bamford, Parry, Shepherd, & Quigley, 2000; Gravel & Traquina, 1992; Madell, 2008; Parry, Hacking, Bamford, & Day, 2003; Primus, 1992; Shaw & Nikolopoulos, 2004; Widen et al., 2000). VRA uses operant conditioning techniques, rewarding the child with a visual stimulus after an appropriate head turn in response to an auditory stimulus (Karzon & Banerjee, 2010; Madell, 2008; Moore, Thompson, & Thompson, 1975; Shaw & Nikolopoulos, 2004). Children are easily conditioned to the VRA task because of the orientation reflex, which is the tendency of a child to look in the direction of a moderately intense, interesting auditory stimulus (Karzon & Banerjee, 2010; Suzuki & Ogiba, 1961; Primus, 1992).

VRA can be performed by presenting auditory stimuli in the sound field through a loudspeaker or to each ear individually with the use of earphones (American Speech-Language-Hearing Association [ASHA], 2004). The advantage of using earphones is that ear specific information is obtained. Because testing performed in the sound field does not assess each ear individually, unilateral and asymmetric hearing losses will be missed. Therefore, using earphones allows for a more complete diagnosis of the hearing status.



In pediatric audiology, insert earphones, placed inside the ear canal, or circumaural earphones, placed over the ear, can be used for VRA testing. Successful ear specific testing has been documented with infants 8- to 12-months of age (Widen et al., 2000). However children 12- to 24-months of age may be less tolerant of earphones (Gravel & Traquina, 1992).

Widen et al. (2000) used insert earphones during VRA testing of 3134 infants of 8- to 12-months of age. Reliable responses were obtained for 95% of the infants; however, 44% of infants required two or more test sessions to obtain four minimum response levels (MRLs) in each ear. Reasons for an incomplete test session in this study included habituation, failure to condition, being fussy, abnormal tympanograms, poor test reliability, and refusal of earphones. Refusal of earphones was responsible for only 6% of incomplete test sessions (Widen et al., 2000). This study demonstrates that VRA can successfully be completed using insert earphones with children 8- to 12-months of age, but a limited number of thresholds may be obtained in one test session.

Day et al. (2000) investigated the efficacy of using insert earphones versus sound field testing during VRA with 41 infants 5- to 10-months of age. The 22 infants tested in the sound field gave significantly more MRLs compared to the 19 infants tested with insert earphones, 2.2 and 0.9 MRLs, respectively. Subject irritability was reported as the reason for aborting VRA testing in 10 infants in the insert earphone group compared to 4 infants in the sound field group (Day et al., 2000). Because of this finding, Day et al. suggested it may be beneficial to first obtain sound field responses before proceeding to insert earphones to maximize the information obtained in one test session (Day et al., 2000).

Gravel and Traquina (1992) examined the use of circumaural earphones with children 6- to 24-months of age during VRA. The children were divided into two age groups, a younger group of 6- to 12-month-olds ( $n = 47$ ) and an older group of 13- to 24-month-olds ( $n = 55$ ).

Ninety percent ( $n = 42$ ) of the children in the younger group provided ear specific information compared to 76% ( $n = 42$ ) of the older group (Gravel and Traquina, 1992). Furthermore, children 21- to 24-months of age were the least tolerant of earphones, accounting for 50% ( $n = 9$ ) of the children who were unable to be tested with circumaural earphones (Gravel and Traquina, 1992).

The literature does not present a clear guide for the clinical decision of when to use sound field, insert earphones, or circumaural earphones during VRA testing of 12- to 24-month-old children. Audiologists must decide which transducer to use based on multiple factors during the allotted testing time (Karzon & Banerjee, 2010). One factor that should be considered is the amount of time it takes to place insert and circumaural earphones. It has been documented that insert earphones take approximately 70 seconds to place; whereas, circumaural earphones take only a few seconds to place (Day et al., 2000; Madell, 2008). Placement time is important considering children frequently displace both types of earphones, requiring additional time for replacement during the test session which may result in fewer threshold searches before the child fatigues (Karzon & Banerjee 2010). Another factor to consider is the weight of each type of earphone. Insert earphones are of lighter weight compared to bulky circumaural earphones allowing for more unrestricted head turning (Day et al., 2000; Gravel, 1994; Madell, 2008), which may lead to more head turns during a test session. Other benefits of using insert earphones during testing include eliminating the risk of a collapsing ear canal and minimizing the need for masking air conduction because of the increased interaural attenuation (Clemis, Ballard, & Killion, 1986; Day et al., 2000; Gravel, 1994; Sklare & Denenberg, 1987).

The purpose of the current study was to directly compare the use of insert earphones and circumaural earphones in children 12- to 24-months of age during VRA. Study questions

included the following: 1) What is the overall acceptance rate of earphones in this population? 2) Is there a difference in the acceptance rate for insert versus circumaural earphones? 3) If there is a significant difference, is it statistically and clinically significant? 4) Is there a significant difference in the acceptance rate for insert and circumaural earphones dependent on age, gender, and hearing status? 5) What behavioral criteria do audiologists use to discontinue testing with earphones? 6) If insert or circumaural earphones are rejected, what percentage of participants can be redirected for further VRA through the loudspeaker?

## **Method**

### **Participants**

One hundred twenty-two participants were recruited for this study. Participants included children 12- to 24-months of age who were referred to the Department of Otolaryngology at Washington University School of Medicine and the Department of Audiology at St. Louis Children's Hospital. This study was conducted in a fast-paced clinical setting. Common reasons for participant referral to audiology included repeated middle ear infections, tympanostomy tube placement, ototoxic monitoring, delayed speech and language, and suspected hearing loss. Participants were recruited in accordance with procedures approved by the Human Research Protection Office of Washington University in St. Louis.

### **Equipment**

VRA was conducted in double-walled sound treated test booths (Acoustic Systems). Testing was completed using a GSI-61 or Otometrics Madsen Orbiter audiometers. Audiometers were calibrated annually to American National Standards Institute specifications (ANSI S3.6-2004). Stimuli were presented via loudspeakers in the sound field, TDH-39 earphones, ER-3A earphones, or B-71 bone conduction oscillator.

Six toy animals, three on each side of the participant, were used for visual reinforcement. The animals were encased in dark Plexiglas boxes and could be illuminated with or without animation. The Plexiglas boxes were located 30 inches from the participant at a 90 degree azimuth to the left and to the right of the participant. Toy animals in test booth 1 included a donkey, pig, cow, penguin, and two bunnies; test booth 2 included a moose, bear, elephant, tiger, and two rhinos; test booth 3 included a pig, lion, two different dogs, and two pandas.

### **Procedure**

All participants were tested with VRA in the sound field followed by testing with earphones. All included participants were tested with a re-test reliability of fair or better. Assignment to the circumaural or insert earphone group was counterbalanced with insert earphones on odd dates and circumaural earphones on even dates. Testing was performed by eight audiologists with years of experience ranging from 4 months to 37 years ( $M = 17.2$ ,  $SD = 13.2$ ).

The protocol was designed to obtain clinically important audiometric information for each participant while maintaining a level of consistency across testers. VRA testing was performed with the participant sitting on his or her guardian's lap in a chair centered in the test room. Loudspeakers were located at a 45 degree angle to the left and right of the participant. A trained assistant was seated in front of the participant to provide a mild distraction at the midline during testing. The assistants included the eight audiologists, two trained assistants, and three third-year graduate students. The audiologist sat in the control booth and presented the stimuli. The assistant and audiologist maintained communication during the test session via a talk back system.

The participant was conditioned to the VRA task by pairing monitored live voice (MLV) speech stimuli, presented at a suprathreshold level, with the reinforcement of the light-up animal toy. The conditioning level was determined by the audiologist based on participant case history, parent report, and personal observation with the goal conditioning level occurring at 30-40 dB SL. Once the participant was conditioned, the audiologist began to search for threshold using 15 to 20 dB step sizes at suprathreshold levels. Five dB step sizes were used to bracket threshold. Threshold was defined as the lowest level at which the participant responded to two of three presented stimuli. Testing was not conducted at intensities lower than 15 dB HL and "normal"

hearing sensitivity was defined as having thresholds at 20 dB HL or lower at all test frequencies (Madell, 2008; Nozza & Henson 1999; Parry et al., 2003; Widen et al., 2000).

Acoustic stimuli included MLV and frequency modulated tones (FMT). Narrow band noise (NBN) at 0.5, 1, 2, and 4, kHz was an option when a child was not responsive to FMTs. When NBN was presented, a correction factor of 5 dB was used when recording the threshold.

Test sessions began in the sound field with threshold searches for a speech awareness threshold (SAT) using MLV followed by two frequency specific thresholds selected from the following: 0.5, 1, 2, or 4 kHz. Frequencies were selected based on case history. For example, the audiologist may have chosen 0.5 and 2 kHz for a participant with chronic middle ear infections, but may instead have chosen 1 and 4 kHz for a participant referred for ototoxic monitoring.

After obtaining a SAT and thresholds for two frequencies in the sound field, testing continued with insert or circumaural earphones to obtain ear specific thresholds. Bone conduction testing was performed after sound field testing if at least one sound field threshold was greater than 20 dB HL, followed by testing with insert or circumaural earphones. If a participant would not tolerate testing with insert or circumaural earphones placement, the audiologist attempted to return to sound field testing to obtain thresholds for the remaining test frequencies.

Participating audiologists completed a worksheet during the VRA test session (see Appendix). The audiologists recorded head-turn responses of the participant during VRA and participant behaviors during insert or circumaural earphone placement and testing. In addition, the audiologists provided an overall subjective rating of participant acceptance of earphones. Subjective rating choices were: “Accept with no fuss”, “Accept with minor fuss”, “Accept with

major fuss”, and “Reject”. Acceptance of insert and circumaural earphones was determined by obtaining at least one ear specific threshold and having a subjective rating of “accept with no fuss”, “accept with minor fuss”, or “accept with major fuss”.

### **Analysis**

The number of ear specific thresholds obtained in the insert and circumaural earphone groups was compared using the Student’s *t* test. One-way analysis of variance (ANOVA) was used to examine the difference between the number of ear specific thresholds obtained in each of the four audiologist subjective rating groups. Excel and SAS 9.2 were used for data analysis. The criterion used for statistical significance was  $p < .05$ .

## Results

Of the 122 participants tested, 86 participants were included in data analysis. Thirty-six participants were excluded from analysis for various reasons including: experimenter error ( $n = 12$ ), developmental delay ( $n = 2$ ), not able to condition to VRA in the sound field ( $n = 3$ ), using video VRA instead of animated toy VRA ( $n = 2$ ), and fatigue during bone conduction testing before earphones could be used ( $n = 17$ ). Information about the included subjects is shown in table 1 and information about the excluded participants is shown in table 2.

The average number of ear specific thresholds obtained with insert and circumaural earphones is shown in figure 1. There was a significant difference in the number of ear specific thresholds obtained between the insert earphone group ( $M = 5.2$ ,  $SD = 3.1$ ) and the circumaural earphone group ( $M = 3.5$ ,  $SD = 3.2$ ),  $t(84) = 2.36$ ,  $p = .02$ , with more ear specific thresholds obtained using insert earphones.

Figure 2 shows the average number of ear specific thresholds obtained with insert earphones and circumaural earphones based on the age of the participants. Participants were divided into two age groups: a younger group (12 to 17 months) and an older group (18 to 24 months). There was a significant difference found for the 18- to 24-month-old participants,  $t(28) = 4.05$ ,  $p < 0.001$ . As shown in figure 2, participants 18- to 24-months of age provided a mean of 6.7 ( $SD = 3.5$ ) ear specific thresholds when tested with insert earphones compared to only 2.5 ( $SD = 2.2$ ) ear specific thresholds when tested with circumaural earphones. No significant difference was found for the 12- to 17-month-old participants,  $t(54) = .55$ ,  $p = 0.59$ .

Figure 3 shows a scatter plot of the number of ear specific thresholds obtained with insert and circumaural earphones as a function of age. A Pearson correlation coefficient was used to assess the relationship between the number of ear specific thresholds obtained and age of the



participants. There was a weak positive correlation found with insert earphones,  $r = .20$ , and a weak negative correlation found with circumaural earphones,  $r = -.17$ . Age did not account for a large proportion of variance in the number of ear specific thresholds obtained for the insert group,  $R^2 = .04$ , or for the circumaural group,  $R^2 = .03$ .

Figure 4 shows the average number of ear specific thresholds obtained with insert and circumaural earphones based on gender of the participants. No significant difference was found in the number of ear specific thresholds obtained with insert or circumaural earphones for males,  $t(55) = 1.78$ ,  $p = .08$ , or for females,  $t(27) = 1.79$ ,  $p = .08$ . However, as seen in figure 4, there is a trend for obtaining approximately two more ear specific thresholds when using insert earphones for both male ( $M = 5.3$ ,  $SD = 3.0$ ) and female participants ( $M = 5.2$ ,  $SD = 3.6$ ) compared to circumaural earphones ( $M = 3.7$ ,  $SD = 3.5$  and  $M = 3.1$ ;  $SD = 2.7$  respectively).

Figure 5 shows the average number of ear specific thresholds obtained based on audiologist subjective rating of acceptance. A one-way analysis of variance (ANOVA) was used to examine the difference between the number of ear specific thresholds obtained in each rating group (“accept with no fuss”, “accept with minor fuss”, “accept with major fuss”, and “reject”). A statistically significant difference between groups was found,  $F(3,82) = 2.74$ ,  $p < 0.05$ . As can be seen in figure 5, as the level of acceptance improves, the number of thresholds obtained increases. Thus, participants rated as “accept with no fuss” ( $M = 4.9$ ,  $SD = 3.2$ ) obtained approximately 1 additional ear specific threshold than participants rated as “accept with minor fuss” ( $M = 3.9$ ,  $SD = 3.4$ ) and approximately two additional ear specific thresholds than participants rated as “accept with major fuss” ( $M = 3.0$ ,  $SD = 2.3$ ).

Figure 6 shows the proportion of subjective ratings for participants in the insert and circumaural earphone groups. There was a high rate of acceptance for both types of earphones,

with no participants rejecting insert earphones and only 6% ( $n = 3$ ) rejecting circumaural earphones. Using ratings of “no fuss” and “minor fuss” as a more reasonable clinical standard of acceptance also yielded a high rate of acceptance, with a 95% ( $n = 35$ ) acceptance rate for insert earphones and a 86% ( $n = 42$ ) acceptance rate for circumaural earphones.

## Discussion

There was a high rate of acceptance for both types of earphones based on subjective ratings of the audiologists (see figure 6). However approximately two more ear specific thresholds were obtained when using insert earphones (5.17 thresholds) than circumaural earphones (3.44 thresholds). Two additional threshold estimates is clinically significant in the pediatric setting.

There appears to be an age factor (see figure 2). The older group of 18- to 24-month-old children yielded an average of 6.73 thresholds with insert earphones compared to 2.47 thresholds with circumaural earphones. These preliminary findings are in agreement with the Gravel & Traquina (1992) who reported that older children 21- to 24-months of age are less tolerant of circumaural earphones compared to younger children. The current results suggest that this older age group is more tolerant of insert earphones. Of note, 5 out of the 11 participants in the 18- to 24-month-old age group and tested with insert earphones provided a very high number, that is 10 ear specific thresholds (see figure 3). These five participants contribute to the high average in this group. A full compliment of participants is needed to determine definitively if there is an age factor. The differential was not significant for the younger group of 12- to 17-month-old children, that is, 4.62 thresholds with insert earphones compared to 4.13 thresholds with circumaural earphones.

Behaviors observed during testing with earphones are shown in table 3. The behavior observed most often in both groups was pulling out the insert earphones ( $n = 13$ ,  $M = 2.8$  times) and pulling off the circumaural earphones ( $n = 11$ ,  $M = 3.6$  times). This behavior did not cause testing to be discontinued. In all such cases, the assistant re-placed the earphones and additional thresholds were obtained. Although insert earphones take longer to place compared to

circumaural earphones (Day et al. 2000), this does not appear to be a factor that negatively influenced results in the present study.

The behavior observed second most often was a failure to respond to suprathreshold stimuli presented through earphones. As seen in table 3, more participants exhibited this behavior in the circumaural group ( $n = 11$ ) compared to the insert group ( $n = 4$ ). This behavior resulted in discontinuing testing with earphones in all 15 cases. The heavier weight of circumaural earphones may explain the difference between the failure to respond rate between the two earphone groups (Day et al., 2000; Gravel, 1994; Madell, 2008). Additionally, using earphones as the sound source minimizes localization cues making it more difficult to determine the side of stimulus presentation (Day et al., 2000; Primus, 1992). Primus (1992) examined the role of localization during VRA by presenting stimuli from a loudspeaker in three positions: adjacent to the reinforcer, directly over the head of the participant providing little to no localization cues, and opposite the reinforcer. It was found that conditioning was more successful and more thresholds were obtained when the sound source was adjacent to the reinforcer compared to directly over the head or opposite the reinforcer (Primus, 1992). In the present study, the lack of localization cues due to earphone use may have caused confusion for the 15 participants, resulting in a failure to respond to the stimuli. Also of note, the participants in the present study were conditioned in the sound field and thus had use of localization cues when learning the head- turning task. Future studies should be conducted starting the test session with earphones to determine if the lack of localization cues during conditioning will impact the success of conditioning or the number of thresholds obtained with earphones.

The behavior of crying was recorded in seconds and was divided into two subcategories: “crying with a response” and “crying without a response”. As seen in table 3, a total of seven

participants were in the “crying with a response” category. These participants began to cry during the placement of earphones but still responded to the presentation of a suprathreshold stimulus. All seven of these participants eventually stopped crying and ear specific thresholds were obtained. There were a total of eight participants in the “crying without a response” category. These participants began to cry during the placement of earphones and did not respond when a suprathreshold stimulus was presented. Five of these participants eventually stopped crying and ear specific thresholds were obtained. The remaining three participants in this category cried for 30-43 seconds without responding before the audiologists discontinued the use of earphones. These three participants were rated as rejecting the earphones. For two of these three participants, the audiologists returned to sound field testing and obtained the two remaining sound field thresholds in both cases.

When considering the use of earphones in the beginning of a test session, many audiologists are concerned that the child will become irritated by the placement of earphones and the test session will have to be terminated before valuable information is obtained. In the present study, 34 participants were returned to sound field testing following poor performance during testing with earphones (see table 4). Of these 34 participants, 70% ( $n = 24$ ) provided at least one additional sound field threshold. When attempted, additional sound field thresholds were obtained for 100% of participants ( $n = 5$ ) who were rated as rejecting the earphones or accepting with a major fuss. This is clinically important because it demonstrates that if a child becomes irritated with earphones during a test session, it is possible to redirect the child to testing in the sound field so audiometric information can still be obtained. It should be noted that the participants in the present study provided at least 3 thresholds before earphones were placed;

therefore, it is likely that this percentage and number of thresholds would be higher if testing was started with earphones before fatigue becomes a factor.

The interjection of bone conduction testing into the test session precluded a definitive analysis of the effect of hearing status on earphone acceptance. In 17 of 25 (68%) cases in which thresholds were elevated, the audiologists proceeded to bone conduction if one or more threshold in the sound field indicated at least a slight hearing loss (25 dB HL or greater). In such cases, bone conduction was performed to confirm the presence of an air bone gap and was in the best clinical interest of these participants. A conductive hearing loss was confirmed in 13 of the 17 cases. In the remaining four cases, bone conduction thresholds were not obtained due to participant irritability. For future studies, children with a known hearing loss should be recruited and tested with insert and/or circumaural earphones to determine if hearing status affects the acceptance of earphones during VRA.

### **Conclusion**

There was a high rate of acceptance for both insert and circumaural earphones for participants 12- to 24-months of age. Of clinical importance, more ear specific thresholds were obtained when using insert earphones, especially for participants 18- to 24-months of age. It was also found that when attempted, the majority of participants were successfully redirected to sound field testing when earphones were not tolerated. These findings demonstrate that children 12- to-24 months of age can be successfully tested with both types of earphones, however insert earphones resulted in significantly more ear specific thresholds compared to circumaural earphones. These preliminary data support the use of insert earphones to obtain a more complete diagnosis of hearing status when performing VRA with children 12- to 24-months of age.

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## Appendix

### Audiologist Worksheet

Assigned Condition:

Insert \_\_\_\_\_ (Odd dates)

Earphones \_\_\_\_\_ (Even dates)

1. Mark a (+) for every true response (including conditioning). Mark a (-) for a no response
2. Start in the sound field with SAT, then pick 2 frequencies
3. Move on to ear specific testing and record on additional sheets
4. Record any behaviors with insert/earphone placement
- 5.

#### SOUND FIELD MEASURES

SAT		Frequency _____		Frequency _____	
dBHL	Response +/-	dBHL	Response +/-	dBHL	Response +/-
90		90		90	
85		85		85	
80		80		80	
75		75		75	
70		70		70	
65		65		65	
60		60		60	
55		55		55	
50		50		50	
45		45		45	
40		40		40	
35		35		35	
30		30		30	
25		25		25	
20		20		20	
15		15		15	

Stimulus _____		Stimulus _____		Stimulus _____		Stimulus _____		Stimulus _____	
dB HL	Response +/-	dB HL	Response +/-	dB HL	Response +/-	dB HL	Response +/-	dB HL	Response +/-
	R L SF BC		R L SF BC		R L SF BC		R L SF BC		R L SF BC
90		90		90		90		90	
85		85		85		85		85	
80		80		80		80		80	
75		75		75		75		75	
70		70		70		70		70	
65		65		65		65		65	
60		60		60		60		60	
55		55		55		55		55	
50		50		50		50		50	
45		45		45		45		45	
40		40		40		40		40	
35		35		35		35		35	
30		30		30		30		30	
25		25		25		25		25	
20		20		20		20		20	
15		15		15		15		15	

**Insert/earphone Behaviors:**

Behavior	# of times	Amt. of time	Comments
Pull off or out _____			
Failure to respond _____			
Crying w/o response _____			
Crying with response _____			
Other (specify) _____			

Stimulus _____		Stimulus _____		Stimulus _____		Stimulus _____		Stimulus _____	
dB HL	Response +/- R L SF BC	dB HL	Response +/- R L SF BC	dB HL	Response +/- R L SF BC	dB HL	Response +/- R L SF BC	dB HL	Response +/- R L SF BC
90		90		90		90		90	
85		85		85		85		85	
80		80		80		80		80	
75		75		75		75		75	
70		70		70		70		70	
65		65		65		65		65	
60		60		60		60		60	
55		55		55		55		55	
50		50		50		50		50	
45		45		45		45		45	
40		40		40		40		40	
35		35		35		35		35	
30		30		30		30		30	
25		25		25		25		25	
20		20		20		20		20	
15		15		15		15		15	

## OVERAL JUDGEMENT:

Accepted - “No Fuss” \_\_\_\_\_

Accepted with “Minor Fuss” \_\_\_\_\_

Accepted with “Major Fuss” \_\_\_\_\_

Rejected – would not tolerate \_\_\_\_\_

Table 1  
*Participant Demographic Information*

Group characteristics	Inserts ( <i>n</i> = 37)	Circumaural ( <i>n</i> =49)	Total ( <i>N</i> = 86)
Age range	12 to 22 months (M=16.0, SD=3.0)	12 to 22 months (M=16.5, SD=2.8)	
Males	25	32	56
Females	12	17	29
12-to-17 month olds	26	30	56
18-to-24 months olds	11	19	30
Hearing loss present	3	5	8
Degree of hearing loss	M=29 dB (SD = 6.5)	M=30 dB (SD=5.0)	

Table 2  
*Excluded Participants*

Reason for Exclusion:	Inserts ( <i>n</i> = 17)	Circumaural ( <i>n</i> = 19)	Total ( <i>n</i> = 36)
Experimenter error	4	8	12
Did not condition in the sound field	1	2	3
Developmental delay	1	1	2
Using VVRA instead of VRA	1	1	2
Fatigue during bone conduction	10	7	17

VVRA = video visual reinforcement audiometry

Table 3  
*Behaviors Displayed by Participants*

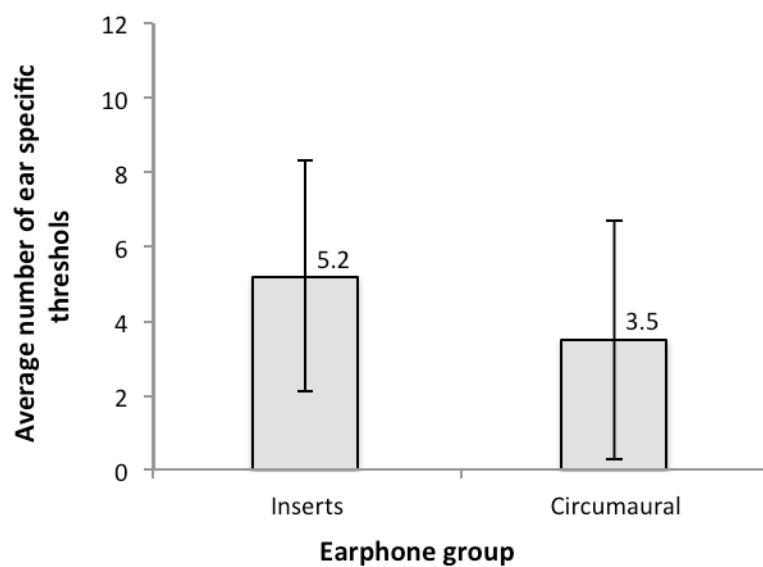
Behaviors:	Inserts ( <i>n</i> = 30)	Circumaural ( <i>n</i> = 36)	Total ( <i>n</i> = 66)
Pull earphones out or off	13	11	24
Failure to respond	4	11	15
Crying with a response	3	4	7
Crying without a response	3	5	8
Other	7	5	12



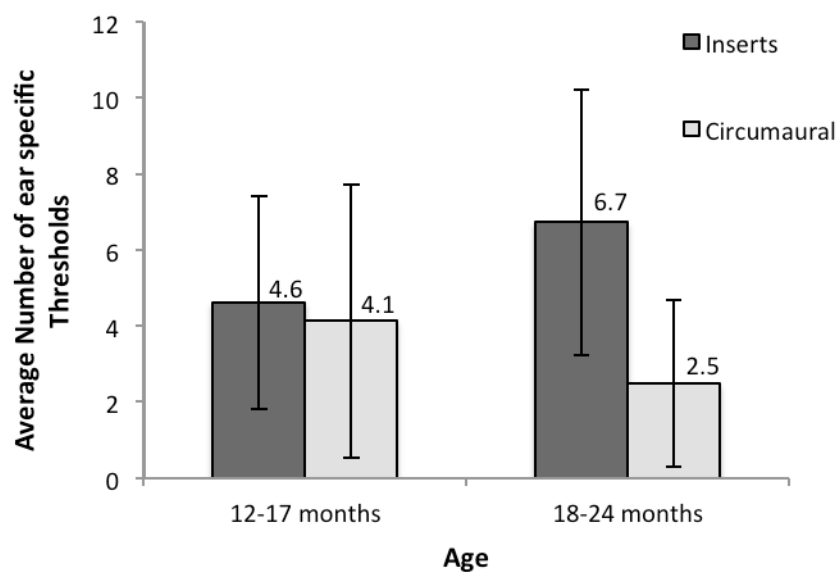
Table 4  
*Participants who Returned to Sound Field (SF) Testing*

Subjective Rating	Total participants ( <i>N</i> = 86)	Returned to SF ( <i>n</i> = 34)	Obtained additional SF thresholds ( <i>n</i> = 24)
Accept with no fuss	44	15	12
Accept with minor fuss	33	14	7
Accept with major fuss	6	3	3
Reject	3	2	2

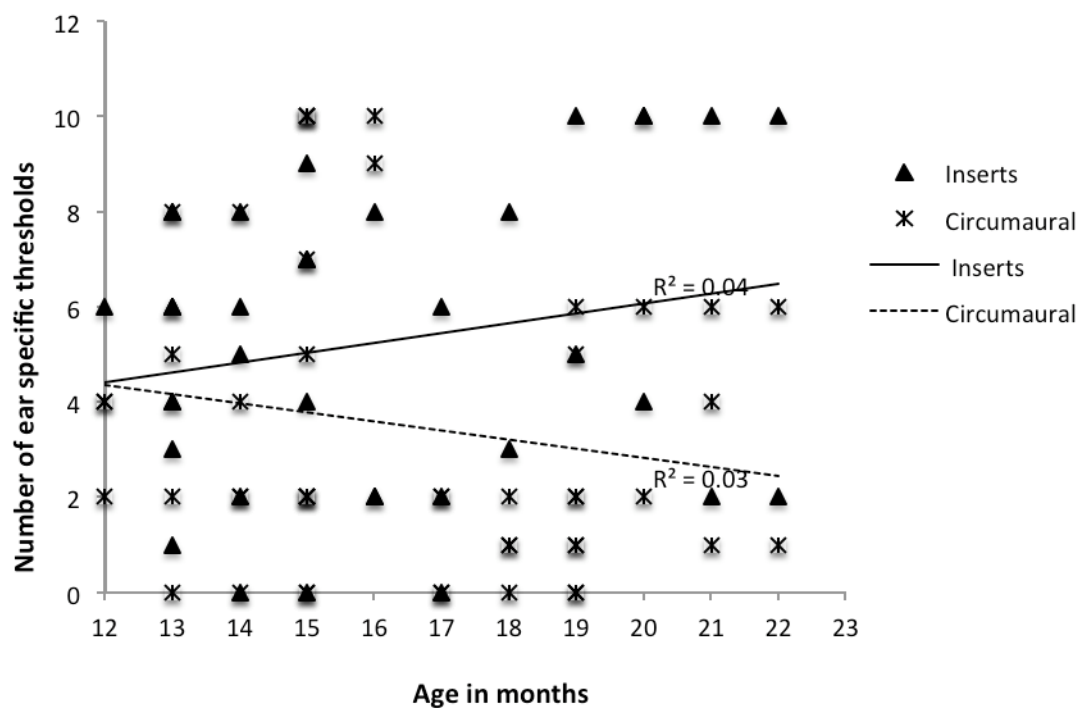
SF = sound field



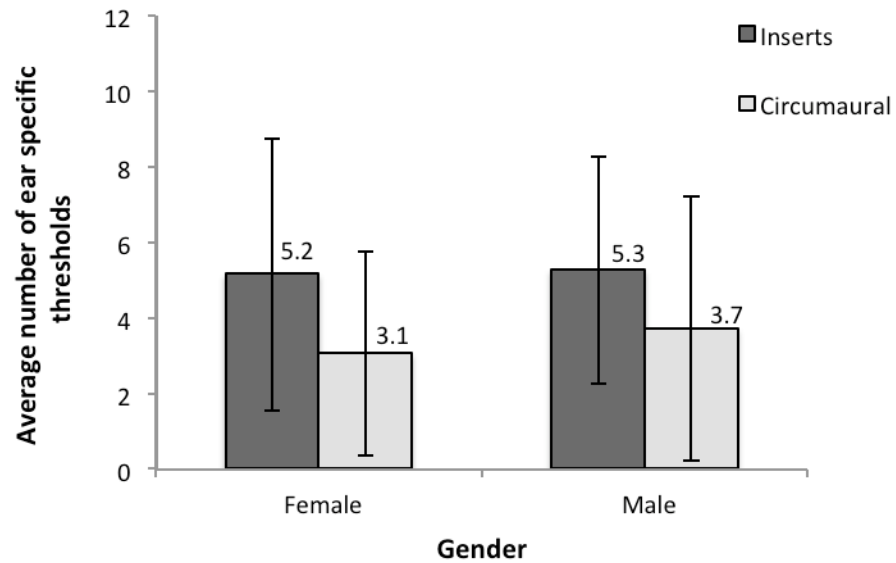
*Figure 1.* Average number of ear specific thresholds obtained for insert and circumaural earphone groups. Significantly more thresholds were found when using insert earphones. Standard deviations are shown on the graph as error bars.



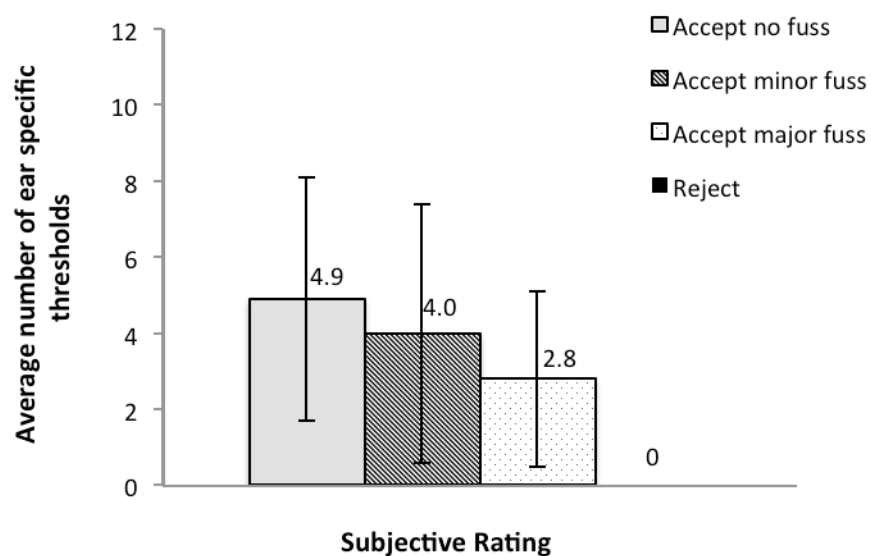
*Figure 2.* Average number of ear thresholds obtained with insert (dark bars) and circumaural (light bars) earphones based on age. Participants were divided into two age groups: 12- to 17-month-olds and 18- to 24-months-old. Significantly more thresholds were obtained using insert earphone in the 18- to 24-month-old group. No significant difference was found in the 12- to 17-month-old group. Standard deviations are shown on the graph as error bars.



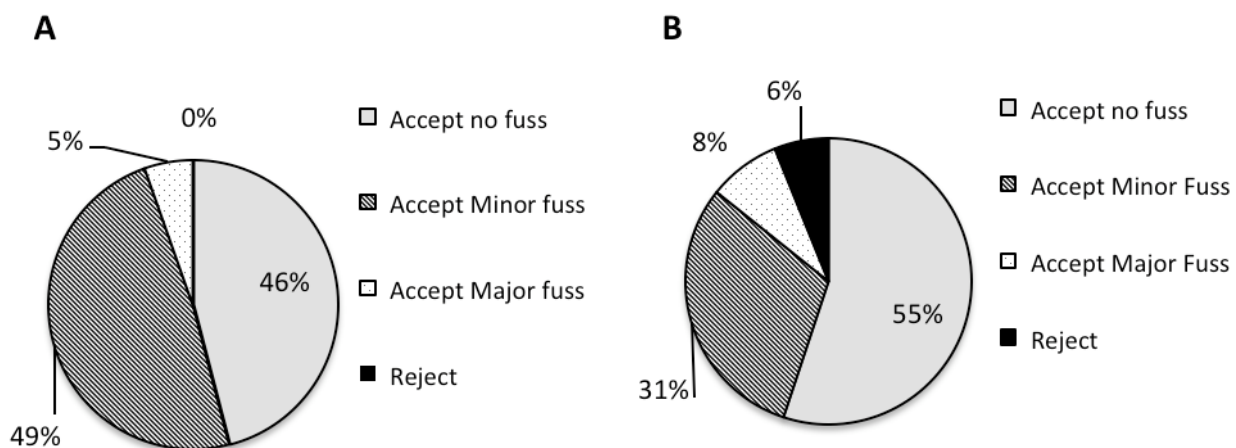
*Figure 3.* Scatter plot showing the relationship between age of the participant and the number of ear specific thresholds obtained with insert and circumaural earphones. Each data point represents one participant. There was a weak positive correlation found with insert earphones and a weak negative correlation found with circumaural earphones.



*Figure 4.* Average number of ear specific thresholds obtained with insert (dark bars) and circumaural (light bars) earphones based on gender. There was no significant difference found between insert and circumaural earphones for males or for females. Standard deviations are shown as error bars on the graph.



*Figure 5.* Average number of ear specific thresholds obtained based on subjective ratings of “accept with no fuss” (light bar), “accept with minor fuss” (hashed bar), “accept with major fuss” (dotted bar), and “reject” (dark bar). There was a significant difference between groups. Standard deviations are shown as error bars on the graph.



*Figure 6.* Pie charts showing the proportion of subjective ratings in insert (A) and circumaural (B) earphone groups. Subjective ratings were “accept with no fuss” (light area), “accept with minor fuss” (hashed area), “accept with major fuss” (dotted area), and “reject” (dark area).